Get Wet Report

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The purpose of this image was to capture a water vortex. This is a commonly known and well-studied flow; however, it has always intrigued me ever since I created one by spinning my water bottle as a kid. This flow is usually very short lived, so I wanted to capture a still photo of it that could show what is going on in as much detail as possible.

To create the water vortex I filled a mason jar with water and stirred it using a spoon. The setup is shown below in figure 1:

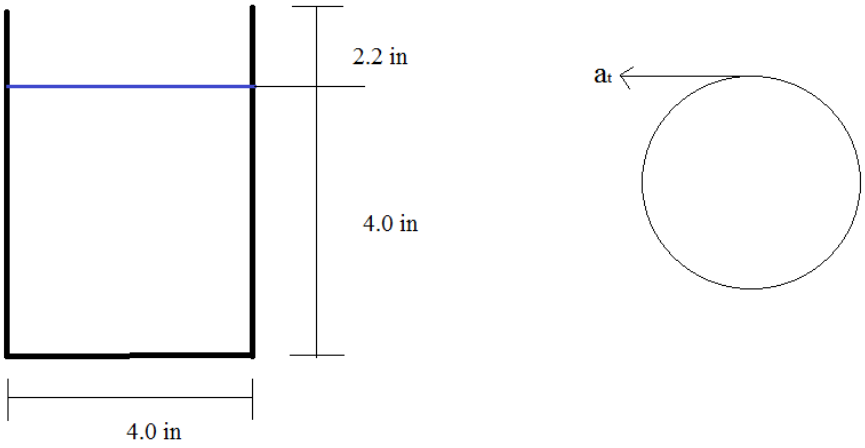

Figure 1 Mason Jar Setup

As the water is spun it has a tangential acceleration component which pushes the water outwards towards the glass of the mason jar. This motion is of course resisted by the pressure in the water. The interaction between these two forces is what causes the water vortex. This is illustrated below in figure 2:

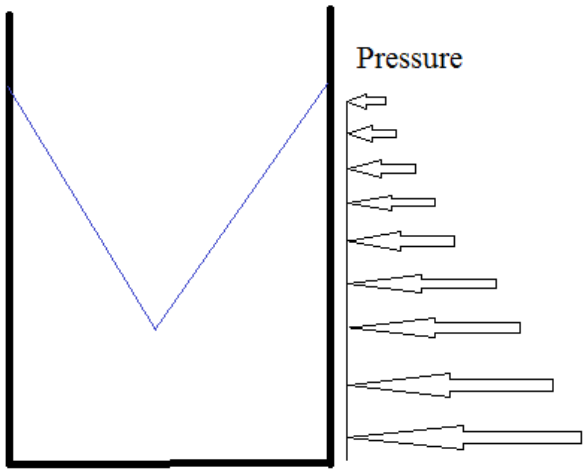

Figure 2 Water Vortex/Pressure Gradient

As shown in figure 2, the pressure increases with depth. Because the water is rotating, it is pushed outwards which is seen at the very top of the vortex, but the pressure is pushing the water back together. This is why the vortex starts out wide and then comes together at a point. For flow in a stirred vessel the Reynolds number is given as $Re = \frac{\rho V D}{\mu}$, where D is the diameter of the agitator, in this case the spoon.(1) In this case D=0.03m, $\rho = 1000\ kg/m^3$, and $\mu = 1.004 * 10^{-6}\frac{m^2}{s}$. For flows of this type a Re > 10000 is considered turbulent. In this case the velocity would have to be extremely small for the Re < 10000 so it is safe to assume this is a turbulent flow.

In this photo there was no need to use a specific visualization technique. The bubbles created by stirring the water were significant enough to show the motion of the flow. Lighting for this image was tricky. I played around with many different setups, using natural light from open windows, shining a desk lamp from various angles, and using a kitchen light directly above. Because of the poor quality glass in the mason jar I found that any light coming from an angle to the glass would cause unwanted reflections. In my final image I settled on just using the kitchen lamp directly above the jar as my source of light. I was however unable to cover all of the surrounding windows so there is still a reflection from one window on that is seen on the left side of the photo.

In this picture the camera was roughly 6 inches away from the mason jar. The focal length in this particular photo was 5mm. This picture was taken on a digital Panasonic DMC-FZ35 camera. My original image had a width of 1920 pixels and height of 1440 pixels while my final image had the same height but a width of only 1674 pixels. I used an aperture of f/2.8, a shutter time of 1/30, and an ISO speed of ISO-100. This aperture was necessary because it was a relatively low light situation, I think I could have had more success if the shutter time was even faster so I could get less blur. Once I got the image into Gimp I added some saturation to the photo and tried to make the background less distracting. A before and after is provided below.

Figure 3 Before

Figure 4 After

I think this image does a good job of revealing the motion and physics behind this flow which was my original intent for this project; however, I also wanted to capture this in as much detail as possible and I believe my image could have been much less blurry. The window reflections on the sides are very distracting, as well as the bright glow at the bottom of the jar. Ideally I should have removed these from the image. Although I like the pattern of the placemat that the jar is sitting on, I got quite a bit of feedback saying this was distracting as well. Next time I would like to have a better setup that would minimize all these distractions, as well as use higher quality glass as to minimize the reflections. This would also allow me to use more light and a shorter shutter speed to reduce blur.

Sources

(1) https://en.wikipedia.org/wiki/Reynolds_number